


## CASE REPORT

# Rare improperly treated traumatic vertical atlantoaxial dislocation: A case report and literature review

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**Background:** Because of the severity and fatal outcome of traumatic vertical atlantoaxial dislocation (AAD), most patients may die in the early post-traumatic period. The post-injury management of patients with vertical AAD has been rarely reported. Improper treatment may lead to disastrous outcome and further aggravate the neurologic symptoms.

**Case Presentation:** This report describes the perioperative management and outcome of a rare improperly treated patient with traumatic vertical AAD. The severe pulmonary infection of this patient prevented further surgery for vertical AAD. After placement of a halo vest, combined with effective antibiotic drug treatment, the patient's pulmonary infection was brought under control. The patient underwent atlantoaxial fusion using C1 lateral mass screws and C2 pedicle screws with the assistance of the halo vest. A computed tomography scan at 1 year follow-up indicated that the bone graft was fused and the patient was able to walk independently.

**Conclusion:** Skull traction is contraindicated in patients with traumatic vertical AAD. Application of a halo vest can be used for temporary fixation of the cervical spine and atlantoaxial fixation should be performed to maintain the stability of atlantoaxial articulation.

**Key words:** Atlantoaxial fixation; Halo vest; Skull traction; Traumatic vertical atlantoaxial dislocation

## Introduction

Atlantoaxial dislocation (AAD) accounts for approximately 2.7% of all cervical injuries.<sup>1</sup> Gonzalez *et al.*<sup>2</sup> proposed a lateral mass index (LMI) greater than 2.6 mm as the criterion for vertical AAD, and the LMI is the longest distance between the lateral masses of C1 and C2. In all types of AAD, traumatic vertical (longitudinal) dislocation is undoubtedly the rarest. In a retrospective study of 300 adult patients with cervical trauma, the prevalence of vertical AAD was estimated to be 1% (3 cases).<sup>3</sup> However, the true percentage of vertical AAD has still not been specified among the general population. In addition, the mortality rate is considerably high.<sup>4</sup> Due to the severity and fatality of traumatic vertical AAD, many patients died before reaching the traumatic emergency

department and reports in the literature are rare.<sup>3</sup> The purpose of this report is to share the perioperative management and outcome of a patient with traumatic vertical AAD transferred to our hospital.

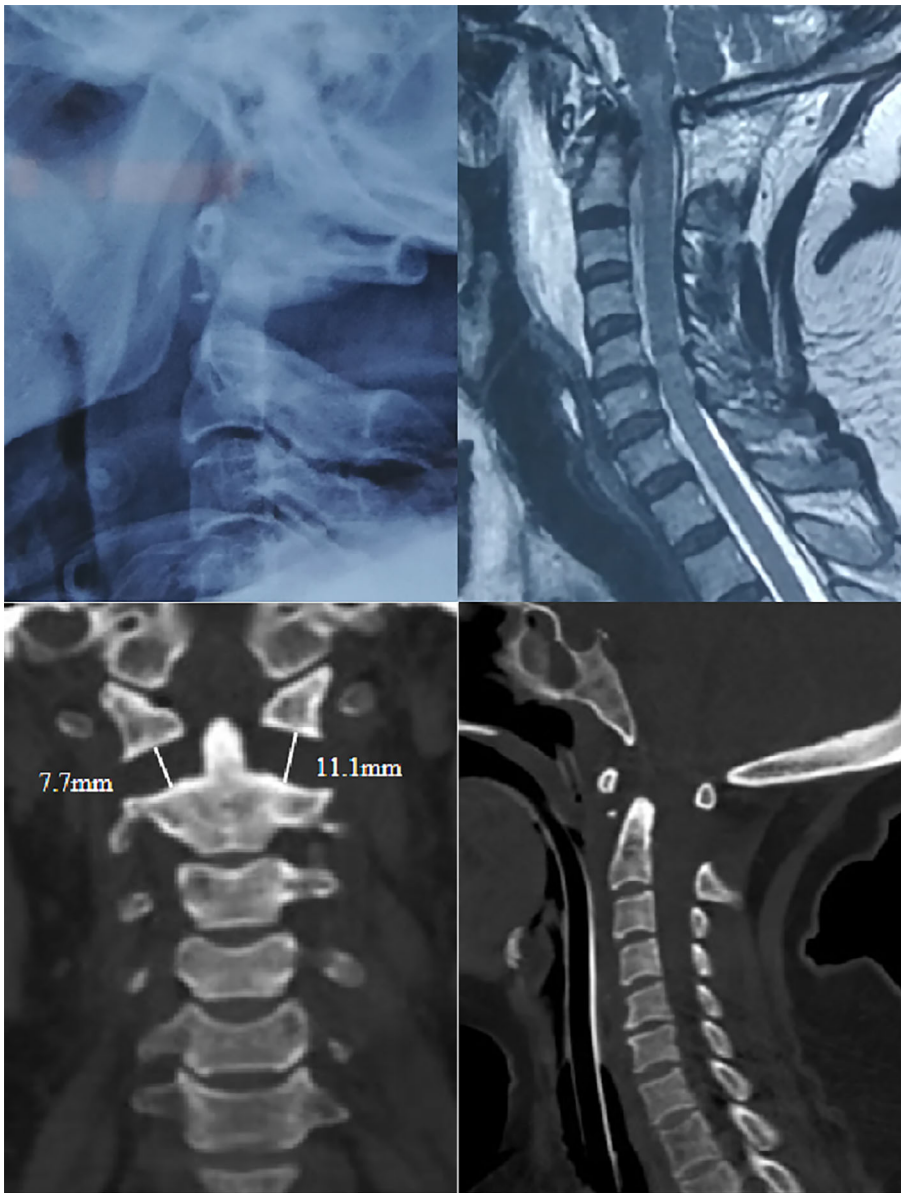
## Case Report

A 59-year-old woman who was knocked down by a motor vehicle complained of neck pain and numbness and weakness in the right upper extremity. The patient was immediately taken to the local emergency department for rescue treatment following injury. While undergoing magnetic resonance imaging, the patient suddenly developed weakness in her limbs. She was immediately subjected to skull traction of 5 kg. The patient suffered cardiorespiratory arrest after traction.

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**Fig. 1** Lateral cervical radiography, magnetic resonance imaging and computed tomography pre-operation showing the vertical atlantoaxial dislocation (AAD)

The traction was immediately removed and the patient was resuscitated with endotracheal intubation simultaneously. Due to hemodynamic instability and the need for respiratory support, the patient was admitted to the intensive care unit (ICU). After 5 days in the ICU, her temperature reached 39°C and chest radiography showed diffuse pulmonary infection. She was transferred to our hospital for further treatment.

On arrival at our hospital, she was lethargic, intubated and on mechanical ventilation. It was difficult to determine her sensory and motor functions. Blood analysis showed that the white blood cell count was  $18.49 \times 10^9/L$  (normal range  $3.5-9.5 \times 10^9/L$ ), the percentage of neutrophils was 88.5% (normal range 40%–75%), C-reactive protein was 263 mg/L (normal range <5 mg/L), interleukin-6 was 127 pg/mL (normal range 0–7 pg/mL), and procalcitonin was 0.82 ng/mL (normal range <0.046 ng/mL).

Sputum culture suggested *Pseudomonas aeruginosa* infection. Lateral radiography of the cervical spine revealed vertical AAD. Whole-body computed tomography (CT) scan showed a vertical AAD with 11.1 mm for the right LMI and 7.7 mm for the left, avulsion fracture of the anterior arch of the atlas, subarachnoid hemorrhage, and pulmonary contusion (Fig. 1).

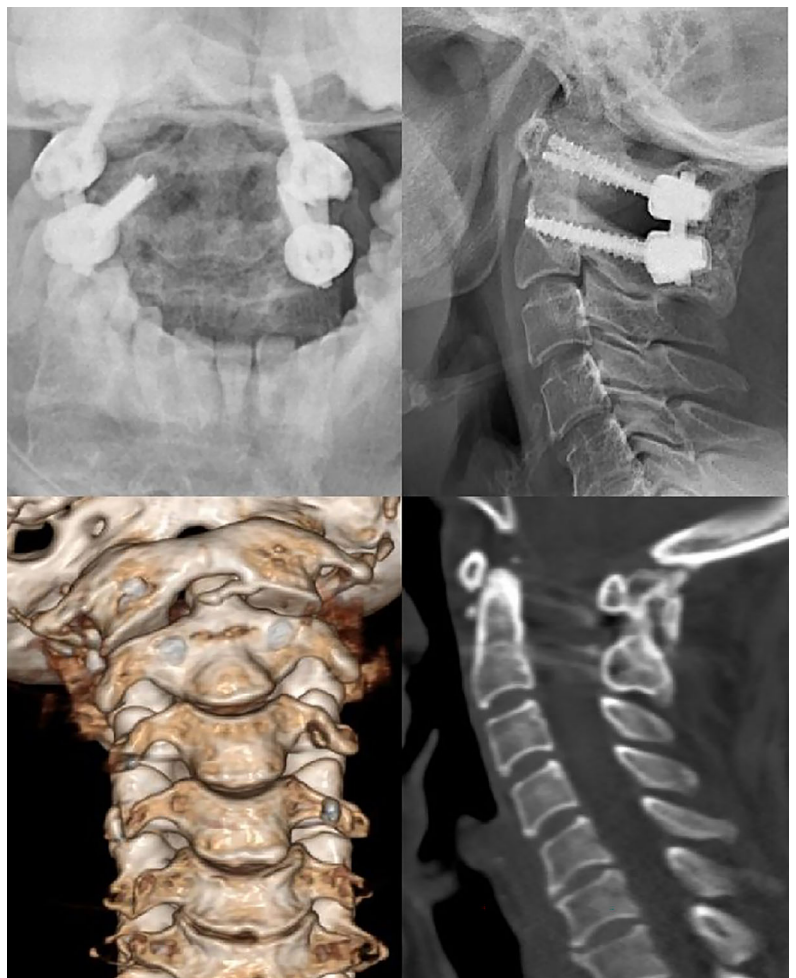
Upon arrival at our trauma center, she was hypotensive and bradycardic despite the use of vasoactive drugs. Her severe pulmonary infection prevented further surgery for vertical AAD. Due to her poor oxygen saturation and pulmonary infection, tracheotomy was immediately performed to facilitate mechanical ventilation and sputum aspiration. A halo vest was used to temporarily immobilize the patient's cervical spine, which allowed the nursing staff to turn the patient over (Fig. 2). In addition, the patient's



**Fig. 2** Lateral cervical radiography after application of the halo vest

bed was adjusted from the horizontal position to an oblique position of  $60^\circ$  to facilitate postural drainage (Fig. S1). Following application of the halo vest, combined with effective antibiotic drug treatment, the patient's infection index decreased and the pulmonary infection was brought under control. Six days after admission, surgery was carried out to correct atlantoaxial misalignment. The patient underwent a C1-C2 fusion using C1 lateral mass screws and C2 pedicle screws with the assistance of the halo vest. Intraoperative fluoroscopy showed satisfactory reduction of the atlas and axis, and the halo vest was removed. Following completion of the operation, the patient was admitted to the ICU for further treatment. Lateral cervical radiography and CT post-operation demonstrated reduction of the vertical AAD (Fig. S2).

One month after the operation, the patient was transferred from the ICU to the Rehabilitation Department for further rehabilitation. The patient's sensorimotor function gradually recovered. A CT scan at 1-year follow-up demonstrated good reduction and complete fusion of C1-2 motion segment (Fig. 3). This patient didn't have any surgery-related complications during follow-up. Her muscle strength in the lower extremities reached 4+ and muscle strength in the upper extremities reached 3+.



**Fig. 3** Lateral cervical radiography and computed tomography at 1 year demonstrating reduction and fusion of the vertical atlantoaxial dislocation (AAD)

**TABLE 1 Literature review: demographic, radiographic features, treatment and prognosis**

Author	Age (Y)/sex	Cause of injury	Pathology	Emergent treatment	Treatment method	Prognosis
Przybylski <i>et al.</i> <sup>4</sup>	35/M	Vehicle accident	Vertical AAD with type III odontoid fracture	Axial skeletal traction (neurological deterioration) Halo vest (neurological improvement)	C0-C4 fusion	Ventilator-dependent high cervical quadriplegic at 1-year follow-up
Weiner <i>et al.</i> <sup>5</sup>	40/F	Pursued by a car	Vertical AAD with atlanto-occipital coalition	Axial compression, halo immobilization	C0-C2 fusion	Ambulation with a quad cane and bilateral knee-ankle-foot orthoses
Ramare <i>et al.</i> <sup>6</sup>	62/M	Car accident	Vertical AAD	Axial compression	Temporary C0-C4 fixation, atlantoaxial arthrodesis	Mild Neurological deficit (muscle score at 4+)
Botelho <i>et al.</i> <sup>7</sup>	16/F	Run over by a vehicle	Vertical AAD	Skull traction (from anterior AAD to vertical AAD)	-	Death
Carroll <i>et al.</i> <sup>8</sup>	19/F	Ejection from a car traveling	Vertical AAD with a fracture of the arch of C1	Halo vest	Philadelphia collar	NO sequelae at 5-year follow-up
Kirkpatrick <i>et al.</i> <sup>9</sup>	65/F	Car accident	Vertical AAD with type III odontoid fracture	Halo vest	C1-C2 arthrodesis	Quadripareisis
	39/F	Car accident	Vertical AAD with type III odontoid fracture	Halo vest	C1-C2 trans-articular screw fixation	ASIA class-A, C5 tetraplegic
	29/F	Car accident	Vertical AAD with type III odontoid fracture and C1 burst fracture	Halo vest	C1-C2 trans-articular screw fixation	Neurological status not available
Payer <i>et al.</i> <sup>10</sup>	64/M	Traffic accident	Vertical AAD	-	-	Death
Jea <i>et al.</i> <sup>11</sup>	73/F	Car accident	Vertical AAD with type III odontoid fracture	Cervical collar	C1-C2 arthrodesis	Ventilator-dependent
Pissonnier <i>et al.</i> <sup>3</sup>	27/M	Traffic accident	Vertical AAD	-	-	Death
	76/M	Fall	Vertical AAD and type II odontoid fracture	-	-	Death
	45/F	Car accident	Vertical AAD and type II odontoid fracture	Skull compression with a Mayfield halo	C0-C3 fusion	Walk 40 meters with help
Russo <i>et al.</i> <sup>12</sup>	22/M	Car accident	Vertical AAD and type III odontoid fracture	-	C1 lateral mass screws and C2 lamina screws	Normal life and work
Park <i>et al.</i> <sup>13</sup>	31/F	Traffic accident	Vertical AOD and AAD with 2-part fractures of the atlas	-	-	Brain death
	21/F	Fall	Vertical AOD and AAD with 2-part fractures of the atlas	-	Occipitocervical fusion	Quadriplegic in a ventilatory-dependent state at 1 year after surgery

## Discussion

Most of the occipital-C1-C2 movement is performed by the atlas and axis, which are susceptible to traumatic injuries.<sup>14</sup> Rupture of the ligaments between the atlantoaxial joint may result in severe vertical AAD.<sup>2,15</sup> However, there are no consistent guidelines regarding the initial care and treatment-related issues of vertical AAD due to its rarity and lethality.<sup>3</sup> Previous reports of vertical AAD are presented in Table 1. Pissonnier *et al.*<sup>3</sup> estimated the prevalence of vertical AAD to be 1% among all cases of adult cervical spine trauma in a systematic review of CT scans. However, this may not truly reflect the prevalence of vertical AAD in the general population. Therefore, clinicians should pay

more attention to this rare but potentially catastrophic injury.

Skull traction is an effective reduction method for most C1-C2 dislocations. Lee *et al.*<sup>16</sup> proposed that early traction of facet dislocation of the cervical spine offered the best chance of neurological recovery. However, Hammer *et al.*<sup>17</sup> reported the lethal development of vertical AAD in a patient after application of skeletal traction. Przybylski *et al.*<sup>4</sup> reported a case of Type III odontoid fracture with initially unrecognized ligamentous disruption of the atlantoaxial complex, who developed longitudinal distraction after traction and rapidly became quadriplegic. Later studies indicated that preoperative traction should be forbidden to avoid irreversible neurological damage



in such cases.<sup>2,3,7,13</sup> In our case, skull traction caused aggravation of the patient's vertical AAD and led to devastating iatrogenic neurological injuries due to unawareness of vertical AAD. The severe neurological consequences of traction encountered by our patient also suggested that the ban on traction is essential to avoid unnecessary damage.

Hammer *et al.*<sup>17</sup> reported that the use of a halo vest in their obese and paralyzed patient caused severe excoriation, while Carroll *et al.*<sup>8</sup> reported a patient with ligamentous C1-C2 dislocation conservatively treated with a halo vest without neurological sequelae 5 years after initial trauma. In a case report by Weiner,<sup>5</sup> halo immobilization was used for solid fusion. Gonzalez *et al.*<sup>2</sup> suggested that early placement of a halo vest with axial loading would reduce dislocation. After application of the halo vest, our patient was placed in a 60° sloping position for repositioning of C1-C2 dislocation by head gravity. In addition, the temporary halo vest was beneficial for nursing staff in the ICU in order to roll the patient over and discharge sputum in the prone position to reduce complications such as decubital ulcer and pneumonia and for placing the patient in the prone position in the operating room (Fig. S3).

Furthermore, there is consensus that patients with vertical AAD require early internal fixation and fusion as soon as the patient's condition allows.<sup>3,10,13</sup> The surgical methods used to treat traumatic vertical AAD have not been widely unified due to the rarity of vertical AAD. Gonzalez *et al.*<sup>2</sup> recommended atlantoaxial fixation for patients with isolated vertical AAD and occipitocervical fusion for vertical AAD patients combined with atlanto-occipital dislocation (AOD), C1 ring fracture or odontoid fracture. Park *et al.*<sup>13</sup> reported a vertical AAD patient combined with AOD treated with occipito-cervico-thoracic fusion. Our patient underwent atlantoaxial fixation and autologous bone graft fusion in the prone position. Satisfying results at follow-up showed that atlantoaxial fixation is an effective surgical method for

vertical AAD patients without atlantoaxial fracture, AOD and (or) atlas occipitalization.

In conclusion, skull traction is contraindicated in patients with traumatic vertical AAD or potential atlantoaxial ligament laceration. Application of a halo vest can be used for temporary fixation of the cervical spine in patients who are not eligible for surgical treatment. Surgical reduction of vertical AAD should be performed as soon as possible to maintain the stability of atlantoaxial articulation and provide an opportunity for early rehabilitation of the patient.

### Author Contributions

**C**onception and design: Xi Yang and Yueming Song. Acquisition and data: all authors. Drafting of the manuscript: Qiang Zou and Zhongjie Zhou. Critically revising the manuscript: all authors. Technical support: Yueming Song. All authors read and approved the manuscript.

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### Supporting Information

Additional Supporting Information may be found in the online version of this article on the publisher's web-site:

**Fig. S1.** Oblique position of the patient with the help of the temporary halo vest.

**Fig. S2.** Lateral cervical radiography and computed tomography post-operation demonstrating reduction of the vertical atlantoaxial dislocation (AAD).

**Fig. S3.** Prone position in the operating room with the assistance of the halo vest.

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